MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXXIX. *May* 9, 1879. No. 7.

Lord LINDSAY, M.P., F.R.S., President, in the Chair.

Captain Edward Barnes, The Lawn, Belper;

The Rev. William Conybeare Bruce, M.A., St. Nicholas' Rectory, Glamorganshire;

George Thorn Gwilliam, Esq., 35 Lansdowne Crescent, W.;

John Penn Hartree, Esq., M.A., M.B., Strandtown, Belfast;

Charles Augustus Jenkins, Esq., University Observatory, Oxford; and

William Edward Plummer, Esq., University Observatory, Oxford;

were balloted for and duly elected Fellows of the Society.

Extract from the Minutes of the Council, May 9, 1879.

"Since the publication of the *Monthly Notices* of the Society for January 1879 the attention of the Council has been recalled to an article headed 'Notes on the late Admiral Smyth's "Cycle of Celestial Objects &c.," by Herbert Sadler, Esq.,' containing remarks on several of the star measures given in that Catalogue, and also containing a sentence reflecting on the 'Reference Catalogue of Multiple and Double Stars,' forming vol. xl. of the *Memoirs*.

"The Council, feeling themselves responsible for the contents of the Society's publications, cannot but express their regret that they should have authorised the printing of this article in its present form.

"While they desire to uphold to the utmost perfect freedom in the criticism of scientific works, they would at the same time enforce a general rule to exclude from the Society's publications any imputation upon the personal honour or good faith of the authors; and they are sorry to observe in Mr. Sadler's article some remarks which are capable of being, and to the knowledge of the Council have been, construed in a sense which infringes this rule.

"The Council are, moreover, of opinion that Mr. Sadler was not justified in passing a sweeping condemnation on the Reference Catalogue, which is irrelevant to the rest of the article, and is entirely unsupported by the citation of the instances on which his judgment was founded.'

It was resolved that these resolutions be read at the Meeting of the Society, and printed in the next Number of the *Monthly Notices*.

Note on Sir John Herschel's Reference Catalogue of Double Stars. By Professor Pritchard, F.R.S.

Those astronomers who are seriously engaged, or otherwise interested, in the computation of the orbits of double stars, or are engaged in furnishing data for such investigations, are informed and requested to bear in mind that Sir John Herschel's references to the Catalogues of the two Struves apply solely to the Catalogues as originally published by those most eminent astronomers, and are independent of the corrections which they subsequently found it necessary to make to their original printed observations.

To working astronomers it may perhaps be unnecessary to add that they will find the corrigenda on consulting *Positiones Mediæ*, page xcii., or the *Recueil des Mémoires présentés à l'Académie des Sciences par les Astronomes de Poulkova etc.*, t. I., St.-Pétersbourg, 1853.

Order of Publication of successive Volumes of the Poulkova Observations. By M. Otto Struve.

(*Extract from a Letter to A. M. W. Downing.*)

In reply to your letter, I beg leave to inform you that vol. viii. of the *Observations de Poulkova* is not yet published. According to a resolution formerly taken, vol. viii. is designed for the Catalogue to be deduced from the meridian observations inserted in vols. vi. and vii. This Catalogue, though the reductions are considerably advanced, is not yet finished; and its publication has been considerably delayed by the lamented death of Dr. von Asten, to whom the work had been entrusted. For these reasons it can hardly be expected that vol. viii. will be published and distributed before 1881. In a similar way vol. x. of the *Observations* is designed to contain the continuation of my micrometrical measures of double stars, but as yet I have hardly been able to begin the reduction of these measures. Therefore vol. x. will not appear for a couple of years; whilst vol. xi., containing the continuation of our fundamental determinations

with the transit instrument, is nearly ready, and will be distributed very shortly.

Similar inquiries to yours have been addressed to me from different quarters. To prevent further misunderstanding, I would feel very much obliged if you would insert in the *Monthly Notices* this account of the reasons why vols. viii. and x. of the *Observations de Poulkova* will be published considerably later than respectively vols. ix. and xi.

Pulkowa, 1879, March 24.

The Nautical Almanac for 1882.

The Superintendent communicates the following errata, which, as referring to the Transit of *Venus*, are of unusual importance:—

'Presentation copies of the *Nautical Almanac* for 1882 to public Observatories, Institutions, and a few others, require the following corrections:

Page 402	*for*	contact at Ingress 129°	*read*	145°
„		contact at Egress 79°	„	114°

'The remainder of the impression has been corrected.'

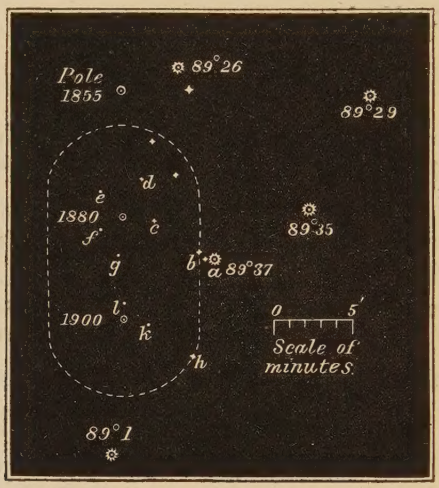
Stellar Magnitudes; a Request to Astronomers.

By Edward C. Pickering, Director of the Harvard College Observatory.

The scales adopted by different observers in their estimates of stellar magnitudes differ considerably from each other, as is well known. As regards the brighter stars, these differences, indeed, are comparatively unimportant; but they become larger and more perplexing when the objects observed are faint. Variations of three or four magnitudes may be expected between the estimates made of the brightness of minute companions seen near a brilliant star. It is needless to point out the inconvenience of this state of affairs, which at times nearly deprives the estimated magnitudes found in Catalogues of their meaning, and consequently of their value.

In the hope of providing a partial remedy for this defect, a series of Photometric Observations of Stars of various magnitudes, situated near the North Pole, has been undertaken at the Harvard College Observatory. The region has been selected as one which may always be conveniently observed in the northern hemisphere, so that the brightness of a star observed in another part of the sky can readily be compared by estimate with any standard polar stars the relative brightness of which may have been determined by photometric measurements.

The table and chart given below are designed to serve as guides in finding the stars which are, as has been said, in course of photometric measurement at the Harvard College Observatory. The stars given in the table are arranged approximately in the order of their brightness, the first being *α Ursæ Minoris*, which is taken in all cases as the standard of comparison, and the next three, *δ Ursæ Minoris*, 51 *Cephei*, and λ *Ursæ Minoris*.



DM.		α 1880.		δ 1880.	
°		h	m	°	′
88	8	1	14	88	40
86	269	18	11	86	37
87	51	6	44	87	14
88	112	19	44	88	57
88	4	0	51	88	23
88	9	2	3	88	36
89	3	2	28	89	36
89	35	17	50	89	48
89	37	19	28	89	54
89	1	0	19	89	45
89	26	13	23	89	49

The chart is a copy of a sketch showing the approximate relative position of ten faint stars very near the pole, which are denoted by the italic letters *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *k*, *l*. The places of the pole for 1855, 1880, and 1900, and of five stars from the *Durchmusterung*, four of which occur in the table, are also

indicated upon the chart, to facilitate the identification of the faint stars. The objects called *c* and *e* are nearly in the prolongation of the line through DM. 89° 37 and *b*. Between these last, and more nearly in the same line than it appears to be in the chart, lies the star *a*.

The value and interest of the photometric results to be obtained at the Harvard College Observatory may be greatly increased by the co-operation of astronomers elsewhere. All who are desirous of improving the present system of comparing the brightness of stars are therefore requested to make estimates of the magnitude of as many as may be convenient of the stars above mentioned. It is desirable that the estimate should be made, for each star which may be observed, on five different nights, and that each estimate should be, if possible, entirely independent of those previously made. It will add to the value of the work if, on every occasion when the fainter stars are looked for, a record is made of such of them as can then be seen, even if no estimate of their magnitudes is attempted.

Observers are also requested to note the approximate places of any stars not represented upon the chart, but within five minutes of the place of the pole at any time between 1880 and 1900. The boundary of this region is represented on the chart by a dotted line. The stars not shown within it have been omitted as unnecessary for the purpose of finding the others, and several of these omitted stars are inconveniently faint for photometric observation; but records of their visibility at any time and place will be valuable as evidence of the state of the atmosphere and character of the instrument employed in the observations.

All astronomers who may be induced by this request to make any observations of the kind just described will confer a favour upon the Harvard College Observatory by sending to it a copy of their records, accompanied by a statement of any modification of the proposed method of observation which they may have adopted, as well as any additional details which may appear desirable, with regard to the instruments employed, &c. Unless the contrary is requested, the results will be published with the photometric measurements obtained at the Harvard College Observatory; and a copy of the publication will be sent to each observer who has co-operated in the work.

It is hoped that a large number of those astronomers whose experience has been sufficient to establish a definite scale for their estimates of stellar magnitude will consent to take part in the proposed observations, in order that the published series of observations may be complete enough to be of general utility.

On the Determination of the Solar Parallax from the Parallactic Inequalities in the Longitude of the Moon, and on the Correction to Hansen's Coefficient of the Annual Equation.

By E. Neison, Esq.

It has long been well known that if it were possible to determine from observations the true value of the coefficient of the parallactic inequality in the longitude of the Moon, it would furnish a most advantageous method of ascertaining the distance of the Sun with great accuracy. For the coefficient of the parallactic inequality is equal to the solar parallax multiplied by nearly fifteen, so that an error of $0''\cdot15$ or a little less than one-sixth of a second of arc in the value of the parallactic inequality would produce an error of only $0''\cdot01$ in the value of the solar parallax. A number of attempts have been made to ascertain the real value of the parallactic inequality in the longitude of the Moon, by comparing the observed place of the Moon with the place assigned to it by the tables, and, from the difference between observation and theory, deducing by known methods a correction to the value of the parallactic inequality employed in the tables. In this way various values have been obtained for the coefficient of the parallactic inequality, ranging between $123''\cdot5$ deduced by Burckhardt, and $126''\cdot46$, the last result deduced by Hansen. These correspond to values of the solar parallax of $8''\cdot63$ to $8''\cdot90$.

The tables with which the observations were compared were up to 1862 unsatisfactory, which rendered the determination of the corrections to the tabular values far less certain than was desirable, unless a very long series of similar observations could be obtained. Since that period Hansen's Tables have been generally employed, and being much more complete and accurate than any previous tables, it much facilitates the comparison of observation and theory and the deduction of corrections to the values of the inequalities employed in the tables.

From the latest investigation it would appear that the value of the parallactic inequality employed by Hansen in his tables is $2''\cdot0$ too great, and ought to be reduced to $124''\cdot46$, corresponding to a solar parallax of $8''\cdot67$. Unfortunately, this apparent correction is not really the true correction to the coefficient of the parallactic inequality, but is really the sum of the true correction to the coefficient of the parallactic inequality *plus* a periodical variation in the apparent semi-diameter of the Moon, due to varying contrast between the brightness of the Moon's limb and the brightness of the sky it is seen against. When the parallactic inequality tends to decrease the longitude of the Moon, then this variation in the semi-diameter tends to increase it; whilst, when the parallactic inequality increases the longitude, then the variation in semi-diameter decreases it. Accordingly, the observed value of the parallactic inequality is always less than the truth.

These drawbacks have now been known for some time, and they have been considered by most competent judges as a fatal obstacle to this method of determining the solar parallax. In this view I by no means concur, on the double ground that, not only are there theoretical objections to the sufficiency of the methods which have hitherto been used to deduce the value of this inequality from observation, but that there are more advantageous methods of accurately determining this inequality than by transits of the Moon's limb. One of these methods is about to be undertaken by Professor Winnecke, and, I am convinced, will lead to the determination of the coefficient of the parallactic inequality to within $0''.1$.

My present purpose, however, is not the consideration of the best methods of obviating these objections to the determination of the solar parallax from the parallactic inequality, but to suggest a method of obtaining the desired result without making use of this inequality, but by employing another which is not liable to the systematic errors peculiar to the parallactic inequality. This term is the term of long period, whose argument is the angular distance between the Sun and the perigee of the Moon's orbit. In my notation it is

$$\theta - \alpha,$$

where θ is the angular distance between the mean longitudes of the Sun and Moon, and α denotes the Moon's mean anomaly. It is what Delaunay denotes by

$$D - l.$$

This term has a period of nearly 400 days, and, being a term of long period, is independent of any errors which may be contained in any of the innumerable terms of short period in Hansen's Tables. It is likewise entirely independent of the uncertainty as to the true value of the Moon's semi-diameter, or of any variations in this semi-diameter. Since Hansen's Tables were introduced, the argument of this term has undergone about thirteen revolutions, and the lunar perigee has nearly completed two revolutions, so that it ought to be possible to determine with some accuracy the value of the ccefficient of this term from the fifteen years' observation of the Moon which are now available. It ought to be possible to determine the value of this term to within $0''.05$, and before long, when the theory of the terms of long period in the Moon's motion is more satisfactorily known, and when a few more years' observation are at my disposal, I think the value of this inequality could be determined from observation to within $0''.02$.

The exceptional freedom of these classes of terms of long period from systematic errors of observation, and their complete independence of the effect of the errors in the terms of short period forming the very great majority of the perturbations of the

Moon, render it very easy to determine their value from observation with very small error indeed.

In this term of long period the solar parallax is multiplied by the factor 2·118; it is therefore less favourable than the 14·25 of the well-known parallactic inequality. If, however, the value of this term could be determined by observation to within 0″·05, as I surmise, it would give the value of the solar parallax to 0″·023, whereas at present it is uncertain to five times this quantity, and may be anything between 8″·740 and 8″·915.

With the view of determining the solar parallax in this manner, I have deduced the value of this term of long period from the fifteen years' observations with the Greenwich Transit Circle between 1862 and 1876. I should have liked to have had eighteen years' continuous observations, so as to include two complete revolutions of the perigee of the Moon's orbit, and when I can obtain the observations for the years 1877–1879 I shall repeat the work, including these years, so as to obtain a perfectly symmetrical investigation.

During this period rather over 1,500 observations of the Moon were made with the Greenwich Transit Circle, but a number of these had to be rejected as having been made under faulty conditions, as indicated by the notes appended to them. There remained 1,464 good observations which form the basis of the present investigation.

Let

$Q \sin q$ = the term of long period with the argument $(\theta - \alpha)$,

$W \sin w$ = the term of long period with the argument $(2\theta - 2\alpha)$,

$M \sin \mu$ = the annual equation, μ being the mean anomaly of the Sun;

and put δQ, δW, δM for the corrections required by Hansen's tabular coefficients of these terms, these coefficients being Q, W, M.

Further, put

δl = the correction required by Hansen's value of the Moon's mean longitude,

$\delta\epsilon$ = the correction to Hansen's value of the Moon's mean longitude at the mean epoch of the observations.

Then Δ, the error in the Moon's tabular longitude, was equated to the above corrections in the form

$$\delta Q \sin q + \delta W \sin w + \delta M \sin \mu + \delta l + \delta\epsilon = \Delta.$$

The observations of each lunation were grouped together to facilitate the work, forming a system of 186 sets of equations of the above form.

The great difficulty in comparing Hansen's Tables with the Greenwich observations consists in the remarkable irregularity in the error in the Moon's mean longitude. Whilst the tables

are rapidly falling away from the observed place of the Moon, the rate at which this occurs fluctuates in an inexplicable manner. This is well shown in Professor Newcomb's paper announcing the discovery of the new term due to the action of *Jupiter*. The two most marked breaks occur between the years 1867–1868 and 1870–1871. For this reason I have judged it best to determine $\delta\varepsilon$ separately for each year from the observations of that year.

The terms depending on the errors in the coefficients of the annual equation, and on the perigee term (w = twice the distance of the Sun from the perigee of the lunar orbit), have been introduced for theoretical reasons. It is never safe to assume that the errors of a term of half the period of the particular term which may be being determined will destroy each other in the course of a short number of observations. For this reason the term depending on δW has been introduced. A similar remark applies to the annual equation which has a period only one-ninth shorter than the parallactic term to be determined. My main reason for introducing this term was, however, the fact that my researches had shown me that Hansen's coefficient was faulty, so that it might be expected to exercise some influence.

The final equations were reduced to the system

$$\begin{aligned} 926{\cdot}15\,\delta Q + 21{\cdot}30\,\delta W + 122{\cdot}74\,\delta M &= +\ 29{\cdot}16'', \\ 33{\cdot}54\,\delta Q + 923{\cdot}37\,\delta W + 66{\cdot}61\,\delta M &= -1016{\cdot}29, \\ 90{\cdot}71\,\delta Q + 59{\cdot}01\,\delta W + 948{\cdot}84\,\delta M &= +\ 25{\cdot}82, \end{aligned}$$

which on solution gives the result

$$\begin{aligned} \delta Q &= +0{\cdot}175'', \\ \delta W &= +0{\cdot}101, \\ \delta M &= -1{\cdot}061. \end{aligned}$$

At first sight it would appear that Hansen's value of the annual equation ought to be increased by over a second of arc, but it must be remembered that the effect of determining $\delta\varepsilon$ in the foregoing manner merges the effect of the year's variation in the Moon's mean longitude into the correction to the annual equation. The value of δM really includes both the total correction to the annual equation and a portion of the correction to Hansen's motion in mean longitude.

In forming sin q it has been found convenient to put

$$\sin(\theta-\alpha) = -\sin(-\theta+\alpha) = -\sin(l'-\mathrm{A}),$$

where l' denotes the mean longitude of the Sun, and A the mean longitude of the lunar perigee. Q is therefore equal to the coefficient of the term

$$\sin(\theta-\alpha)$$

with its sign reversed. The above result indicates therefore that Hansen's value of this coefficient ought to be increased by $0''{\cdot}175$, a very considerable increase. From Hansen's *Darlegung* it appears that he has assigned to Q, the coefficient of this term, the value (with its sign reversed)

$$\begin{aligned} Q &= +18''{\cdot}492 \times 1{\cdot}03573 \\ &= +19''{\cdot}152 \end{aligned}$$

The effect of the correction deduced from observation would be to raise this to the value

$$Q + \delta Q = +19''{\cdot}327.$$

It remains to see what effect this change will have in altering Hansen's value for the solar parallax.

For convenience let it be supposed that the solar parallax is $8''{\cdot}75$ and that the Moon's mass is $\frac{1}{81{\cdot}5}$. Then, according to Delaunay, the coefficient of this term ought to be $18''{\cdot}56$, or, as I should make it from his data,

$$Q = 18''{\cdot}578,$$

for he appears to have underestimated the value of the remainder of his series.

Pontécoulant finds for this term the value $18''{\cdot}41$, or rather, from the analytical results of Pontécoulant's *Théorie de la lune*, this value can be deduced, employing the above data, which differs from that made use of by him. But Pontécoulant's coefficient is admittedly deficient in terms involving high powers of e and γ. Supplying these corrections, and allowing for an error which he afterwards detected, his coefficient becomes

$$Q = 18''{\cdot}54.$$

I have made sufficient advance in my own theory to be enabled to supply the principal part of this coefficient from my own researches. The coefficient has the value

$$\begin{aligned} Q = \Big\{ &\frac{165}{32}\mathrm{m} + \frac{5997}{256}\mathrm{m}^2 + \frac{98049}{1024}\mathrm{m}^3 + \frac{8457917}{16384}\mathrm{m}^4 + \frac{193186623}{65536}\mathrm{m}^5 \\ &\quad{}'' \qquad\quad{}'' \qquad\quad{}'' \qquad\quad{}'' \qquad\quad{}'' \\ &+12''{\cdot}0786 \quad +4''{\cdot}4367 \quad +1''{\cdot}4727 \quad +0''{\cdot}6397 \quad +0''{\cdot}2953 \\ &+ \frac{87648232497}{524288}\mathrm{m}^6 + \ldots\ldots \Big\} b^2 e \cdot \frac{1-\lambda}{1+\lambda} = {}''19{\cdot}0584\,\frac{1-\lambda}{1+\lambda}, \\ &\quad{}'' \\ &+0''{\cdot}1354 \end{aligned}$$

where m is as usual equal to $\frac{m}{1-m}$, λ is the mass of the Moon, and b^2 stands for the quantity of the second order $\frac{a}{a'}$, the ratio of the distances of the Sun and Moon. I am not quite sure of the last term being perfectly complete, as it is an order beyond the usual extent of my computations, and I have not yet quite completed this portion. It will be seen that this series converges appreciably quicker than that made use of by Delaunay. Adding to this coefficient the portion necessary to complete the preceding series ($= 0''\cdot0870$), supplying from Delaunay the terms depending on the higher powers of e which I have not yet determined, and replacing λ by its value, the value of this coefficient becomes

$$Q = 18''\cdot5290.$$

All these values agree closely, and there is little doubt but that the value

$$Q = 18''\cdot550$$

is very close to the truth.

There is no difficulty in determining the coefficient of this term with any needed accuracy, for it would not be difficult to push the calculation to the order m^{10}, or, by numerical solution, to determine its value to $0''\cdot001$.

It appears, however, that the value indicated by observation exceeds this theoretical quantity by

$$+0''\cdot777,$$

and if this were really the true value of this coefficient as shown by the observations, it would correspond to a solar parallax of

$$9''\cdot117;$$

this is impossible.

It does not appear possible that there should be anything erroneous in the method of deducing this correction. It might be thought that the method of correcting the equations of condition for errors of longitude and epoch might introduce some systematic error. For this reason the observations were reduced anew in their unaltered form, determining both δl and $\delta\epsilon$ from the total 1,464 observations. The values obtained were

$$\delta Q = +0''\cdot187,$$
$$\delta W = +0''\cdot140,$$
$$\delta M = -0''\cdot586,$$
$$\delta l = +0''\cdot985,$$
$$\delta\epsilon = 1864''\cdot1.$$

These are practically identical with those previously obtained.

I think I shall be able to throw some additional light on this perplexing discrepancy when I have completed my determination of the theory of the terms of long period in the Moon's mean longitude. I am also reducing the Altazimuth observations of the Moon made at Greenwich, and the Washington Transit Circle observations.

I bring the question before the Society because it is important that such things should be made known, and because it throws a good deal of light on the high value of the solar parallax deduced by Hansen. When I commenced my inquiry I believed that I was the first to suggest the employment of this inequality of long period for the determination of the solar parallax. I think I am the first who has explicitly directed attention to its capabilities, and especially to its apparent freedom from systematic error, but I now believe that Hansen had made use of it for this purpose, and that it was mainly from this inequality that he determined the high value assigned by him to the solar parallax, and necessarily to the parallactic inequality. Hansen has nowhere explicitly referred to his having made use of this term for this purpose, but a paragraph in an early paper of his leaves little doubt on the matter, and this view is confirmed by several remarks in his *Darlegung*. The paragraph referred to occurs in a letter in the *Monthly Notices*, vol. xv., p. 9, and is as follows:—

'I may remark further that I have taken into consideration, not only the coefficient of the parallactic inequality itself, but also the largest of the remaining terms depending on the Sun's parallax, and that the aggregate of these terms may amount to the fifth part of the coefficient of the parallactic inequality.'

The first clause would seem clear enough, but the last renders it rather perplexing; for the sum of the three principal minor terms of the parallactic inequalities amount to not one-fifth, but two-fifths of the coefficient of the parallactic inequality. I am not certain, therefore, whether Hansen in this paragraph really alludes to this term of long period, or merely to the two other terms, which, having arguments of short period, are more naturally associated with the parallactic inequality, and the sum of the coefficients of these two terms would amount to one-fifth of the coefficient of this term. I have little doubt but that, subsequently, he did make use of this term of long period, from the tenor of his remarks in the *Darlegung*, though there is no explicit statement of the fact.

As Hansen's Tables now indicate a marked diminution of his coefficient of the parallactic inequality, his making use of this term would serve to explain how he came to render his value too great. Its apparent independence from systematic error would naturally lead to greater weight being attached to its results.

From the second system of equations it appears that Han-

sen's value of the coefficient of the annual equation ought to be increased by more than half a second, although it is already a far larger value than has been arrived at by any other theorist. Hansen's value is 669″·880, whilst Delaunay finds 668″·910, and Pontécoulant 668″·932. I have not yet completed my own result, but I anticipate it will considerably exceed those of both Delaunay and Pontécoulant. It is, however, very desirable to determine the observed value of the annual equation, as it has an important bearing on the value of the parallactic inequality and variation. Moreover, its determination from observation is exposed to a systematic error tending to increase its apparent magnitude, and it is this augmented value which must be considered in discussing the observed place of the Moon with the view of deducing corrections to the other inequalities.

For this reason I was led to more carefully examine the correction required by Hansen's value of this coefficient. The observations were grouped into the three periods 1862–1867, 1868–1870, and 1871–1876, so as to avoid the effect of the sudden changes in the apparent mean motion which made its appearance between 1867–1868 and 1870–1871. These groups were then separately solved in the usual manner, and three accordant values were obtained for the correction to the coefficient of the annual equation. The final result from the three is

$$\delta M = -0''\cdot7294 \pm 0''\cdot0712,$$

and is the result of the reduction of 1,464 observations made with the Greenwich Transit Circle between the years 1862–1876. When thus augmented the coefficient of the annual equation becomes

$$M = -670''\cdot609.$$

This result is greater than any which has been obtained from pure theory, unless Damoiseau's value of 673″·70 be considered as a purely theoretical value. Burckhardt, from observation, found the value 673″·3, but his Tables show this value to be too great. The Astronomer Royal, in his discussion of the Greenwich Observations between 1750 and 1850, was led to the value 670″·04, but considered this value probably too large. In the American Tables the coefficient 670″·3 is employed, and the comparison between the Washington Observations and these Tables shows that it cannot be seriously in error; whereas the comparison between Hansen's Tables and the Greenwich Transit Circle observations at once indicate that there is a discrepancy between the tabular and observed value of this coefficient.

The introduction of these corrections goes far to reduce the apparent irregularities in the motion of the Moon's mean longitude. The rate at which the tables are deviating from the true place of the Moon seems to be decreasing, and to correspond to a

considerable extent to the effect of the faulty determination of the terms of long period in the Moon's mean motion arising from the action of the planet *Venus*.

In a subsequent communication I trust to be able to give a new determination of the parallactic inequality, in which the effects of the variation of the Moon's semi-diameter will be independently determined, and which shall be free from the objection which I think can be urged against the sufficiency of the theoretical basis of the previous determinations. I trust also to be able to remove the remaining irregularities in the apparent motion of Hansen's mean longitude, by tracing them to their source.

The Radiant Points of April 9–12. By W. F. Denning, Esq.

In recently drawing out a Table showing the number of fireballs and bright meteors observed on each day of the year, I was surprised at the large number recorded on April 11–12, July 27–30, November 19, and December 21; and, with the object of finding the chief showers in action during the first of these special epochs, I have just completed the projection of more than 700 shooting stars registered by Zezioli in the years 1867–70, and by other Italian observers in 1869 and 1872. The radiant points derived from these tracks numbered 21, of which several appear to be of more than ordinary richness. The positions of these centres, compared with previous determinations and with Mr. Greg's Catalogue of 1876, are given in the following Table. The major radiants are at π *Herculis*, δ *Ursæ*, and α *Draconis* with more than 40 meteors each. The first of these agrees with two showers found by Schiaparelli from Zezioli's observations, and with one seen by Mr. Corder and the writer in 1877. The average of the four independently assigned centres is at $245^\circ{\cdot}7+51^\circ{\cdot}5$, which accords very closely with the new position at $249^\circ+51^\circ$. The maximum probably occurs on April 11, and the shower is no doubt connected (or included) with Mr. Greg's Draconids I at $263^\circ+50^\circ$ (No. 47). The shower at δ *Ursæ* is equally well defined, and it had been already recognised by Mr. Greg as an active and persistent display with a centre at $180^\circ+60^\circ$. The position at α *Draconis* (which also supplies several showers during the winter months) is not given in his Catalogue, but it falls near a strong radiant at $204^\circ+56^\circ$ (No. 55). No. IV in the Table represents a conspicuous (though diffuse) centre of short meteors in *Coma Berenices*. The shower of Herculids (No. VII) appears to be sharply defined and distinct from several other April radiants near it, and this position may be regarded as very exactly determined from the following observations :—

April 9–12, 1879	257°+37°	25 meteors	D. and others.
April 2–23, 1868–9	256+38	4 radiants	S. and Z.
April 19, 1870	259+41	Stationary meteor	Schulhof.
April 21, 1874	259+38	Stationary meteor	Palisa.
April 20, 1873	257+34	Doubly obs. meteor	Waller.

The average position deduced from the five values is at 257°·6+37°·6. No. VIII at *β Ursæ* has apparently escaped all former observers, except Heis, who gives a very slightly observed shower at the same point, and it is probably different from a radiant further S. in *Ursa* at 162°+48° (Greg 56). A shower diverging from *β Ursæ* has been detected by Mr. Greg and others in the summer months; but, apart from Heis's confirmation of these April Ursids, the only good support given it is by a stationary meteor of the 2nd mag., recorded by Franzi, at Montcalieri, on May 9, 1872, at 163°+58°. Amongst the remaining showers indicated in the Table there are some certain radiants in *Boötes*, *Corona*, and near *η Ursæ*. No. XIII in *Cepheus* is new, and now requires further observation, and the system at 106°+46° in the Lynx, though not of remarkable intensity, appears to have supplied many of the brilliant meteors visible at this special period. One of the most accurately centred showers in the list is that between *α Serpentis* and *α Libræ* (No. XI, 228°−4°). The average of 7 radiants close to this point gives 227°·1−5°·7 as the resulting position which may be regarded as a very certain and exact April shower. There are a few diffuse radiants given in the Table; but these are of little value, as giving merely the general place of divergence of several mixed showers; for scattered or elongated radiants usually have their origin not so much in errors of observation of the path-directions from which they are derived, as from the contemporary activity of two or more bordering systems. Hence it is always important to note the visible features of each meteor as observed, so that those displaying similar characteristics may be arranged together, and disassociated from other streams, each of which it will be found has certain individual points of resemblance that will enable the observer to distinguish the true radiant in many cases.

The Radiant Points of April 9–12, derived from 700 Shooting Stars recorded by Zezioli and other Italian Observers in the Years 1867—1872, compared with previous Observations of the same Showers.

W. F. Denning, 1879.				Other Observers.			Mr. Greg's Catalogue, 1876.		
No.	Remarks.	No. of Meteors.	Position. α ° δ °	Position. α ° δ °	Duration.	Observer.	No.	Position. α ° δ °	Duration.
I	Exact; Draconids I; max. April 11	44	249+51	246+46	Ap. 9	S. & Z. (51)	30, 40	249+45	Feb. 17—Mar. 3.
				240+55	Ap. 14	S. & Z. (58)			
				242+55	Ap.	Corder	47	263+50	Mar. 11—May 31.
				255+50	Ap. 16–19, 1877	D. 77, (41)			
II	Exact; α *Draconis*	43	212+65	210+66	Mar. 31—Ap. 12	D.S. III 19	55	204+56	Ap. 1—May 25
				202+62	May 1869	Serpieri			
III	Fairly exact; δ *Ursæ*; max. April 12	44	184+59	180+60	Mar. 3—Ap. 30	G. & H.	21, 46	180+56	Feb. 6—Ap. 25.
IV	Very diffuse; triple? 178+35, 184+28, 190+32	37	184+32	182+29	Ap. 29	S. & Z. (64)	54	190+24	Mar. 25—Ap. 30.
				198+32	Mar. 25—Ap. 24	G. & H.			
V	Radiant diffuse	26	218+13	217+16	Ap. 13—May 1	G. & H.*	53*a*	226+10	Ap. 1–30.
VI	Coronids	24	236+34	237+35	Ap. 30	S. & Z. (65)	67	235+23	Ap. 12—June 30.
VII	Exact; Herculids	25	257+37	256+38	Ap. 2–23	S. & Z. (49, 50, 60)	47	Positions of S. & Z. averaged with Draconids I (263+50) in Greg's Catalogue.	
VIII	At β *Ursæ*	24	162+59	162+59	Ap. 17–30	Heis, M_8.	56	162+48 Ap. 10–30	This shower is probably quite distinct from the β Ursids.
IX	S. of β *Leonis*	24	178+8	175+8	Ap.—May	Corder	28	175+14	Jan. 8—Mar. 31.
				175+10	Feb. 10—Ap. 2	G. & H.			

X	Exact; in 1869	19	123+40	123+40	Ap. 29—June 12	G. & H.	63	Only seen by G. & H.	
XI	Fairly exact	15	228− 4	228− 2 227− 8 227− 5	Ap. 16–19, 1877 Ap.—May Mar. 20—May 29	D. 77 (39) Corder G. & H.	53	225− 8	Mar. 20—May 29.
XII	Fairly exact	18	202+24	209+18	Mar. 2–3	Tupman (22)	29 39	205+17	Feb. 11—Mar. 3.
XIII	Exact	14	335+62	338+61	Mar. 31—Ap. 12	D.S. III 26	...	New shower in *Cepheus*.	
XIV	Near η *Ursæ*	19	205+43	206+44	Mar. 31—Ap. 12	D.S. III 15	55	204+56	Ap. 1—May 25.
	Uncertain	15	215+54	215+55 212+55	Mar. 30 Ap. 14	S. & Z. (45) S. & Z. (59)			
XV	In *Quadrans*	16	233+47	235+43	May 16—June 2	S. & Z. (67, 71, 77)	71	235+45	May 16—June 2.
XVI	Pair of diffuse radiants in *Serpens*; mean at 236+15	13 11	230+15 243+15	230+ 5 244+15	Ap. 27, 28 March 7	Tupman (32) Tupman (19)	41	248+12	Mar. 2–7.
XVII	Diffuse	13	226+25	218+22 221+20 223+23	Ap. 4—May 7 Ap. 21, 1872 Mar. 31—Ap. 12	Corder Denning D.S. III 29	53*a*	226+10	Ap. 1–30.
XVIII	Fairly exact	14	106+46	98+46	Mar. 19–27	G. & Z.	43	103+39	Mar. 9–27
XIX	Diffuse	10	288+41	284+44 294+41	Ap. 19–23	Denning	New showers not in Greg's Catalogue.		
XX	Exact	9	277+12	277+10	Mar. 31—Ap. 12	D.S. III 24			
XXI	Fairly exact	12	266+26	273+25 267+25	Ap. 13, 1864 Ap. 20, 1872	A. S. Herschel R. P. Greg	50	265+23	Mar. 2—Ap. 25.

A Catalogue of 222 Stationary Meteors. By W. F. Denning, Esq.

The following list of stationary meteors was compiled from the published Meteor Catalogues of Heis, Greg and Herschel, Schmidt, Weiss, Zezioli, Schiaparelli, Tupman, and Konkoly, and from the observations of Clark, Corder, Sawyer, Backhouse, Johnson, and myself. The annual reports of the Luminous Meteor Committee of the British Association were also consulted for the same purpose, and the positions selected from these materials will, it is thought, be of some value either as confirming old, or giving evidence of new, showers; though it is probable that many of the observations refer to meteors with extremely short paths, for unless an observer is looking exactly to that point of the heavens in which the meteor appears, he cannot certainly determine whether or not it is perfectly stationary. And in such cases of extreme foreshortening the nucleus is seen more or less projected upon the streak or offcome of sparks, giving it the appearance of a nebulous star, and rendering it difficult to detect the motion, if any, and assign the direction. Moreover a meteor, even if at the outset travelling in the observer's line of sight, will, as it encounters the variously dense atmospheric layers, sometimes appear to have a slightly curved or sinuous movement which cannot be accurately noted. In such cases the meteor is always very close to the radiant, though not necessarily in the exact centre of it; and it will be found that when several of these short meteors are recorded near the same radiant, their directions do not exactly correspond to the same point of departure as in the sketch (Fig. I.). The true radiant may, however, be found in the midst of these diverging tracks, the central positions of which it is generally easy to determine very accurately, for slowness of motion is a characteristic of these objects, and they leave very bright streaks or rather luminous clouds, especially when the apparition is visible in a region near the Earth's apex. The streaks or trains (visible as light patches) of these nearly stationary meteors are seen throughout their entire depth, and are thus apparently intensified to a considerable degree, whereas in the case of angular long-pathed meteors the streaks are seen only through their width, and their transient faint character is nearly always evident. In some instances where several meteors have been registered as quite stationary, and belong no doubt to the same radiant, there is a difference of a few degrees in their assigned positions which cannot be attributed to errors of observation. A diffused radiant area or the occurrence of two approximate showers might explain this anomaly,

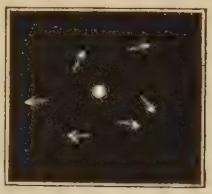


Fig. I.

but it is best accounted for on the supposition that the meteors were not without slight motion, though that motion was inappreciable to the eye. In the case of the August Perseids and April Lyrids there is a group of stationary meteors clustering around the radiant centre. In the instance of the former shower no less than 24 fixed meteors have been recorded between August 2 and 13, and their projected places conform to more than one radiant, as the following diagram (Fig. II.) shows most clearly:—

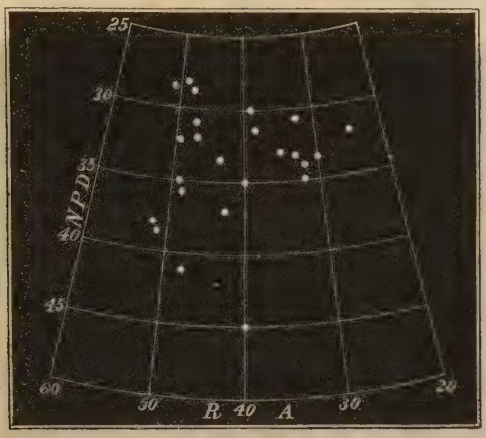


Fig. II.

There is a decided condensation near χ *Persei* and B–C *Camelopardi*, and a number of scattered positions extend in a southerly direction. Separating them into three groups and taking a mean of the observations, we have the following centres:—

I	$47^\circ + 59^\circ$	9 meteors	At B–C *Camelopardi.*
II	$32 + 57$	8 meteors	At χ *Persei.*
III	$46 + 51\frac{1}{2}$	7 meteors	At γ *Persei.*

The average of the 24 positions is at $42^\circ + 56^\circ$, which is close to Mr. Greg's general centre ($44^\circ + 56^\circ$) for the Perseids. Major Tupman's determination of this radiant is at $45\frac{1}{2}^\circ + 56^\circ$ (mean of 28 observations), and Heis gives the chief centre at $45^\circ + 51^\circ$ (A_{11} 425 meteors, August 1–24), which corresponds with No. III of the positions given above. (Two meteors, Nos. 107*a* and 127*a* in the Table, at $44^\circ + 56\frac{1}{2}^\circ$ and $45^\circ + 57^\circ$, August 9 and 10, confirm No. I; but these observations were erroneously omitted from the diagram, and also at first from the Table. Including them we have 26 stationary Perseids.) It is evident,

therefore, that these meteors prove, what has long been observed in connection with this rich stream, that its radiant is apparently diffused over the triangular region from χ *Persei*, γ *Persei*, and B–C *Camelopardi*. The origin of this diffusion probably lies in the fact that there are several concentric streams in simultaneous activity, and giving meteors exhibiting identical features.

The stationary meteors observed in the region of *Lyra* during the period from April 19–23 are more scattered than in the case of the Perseids, as shown in Fig. III.

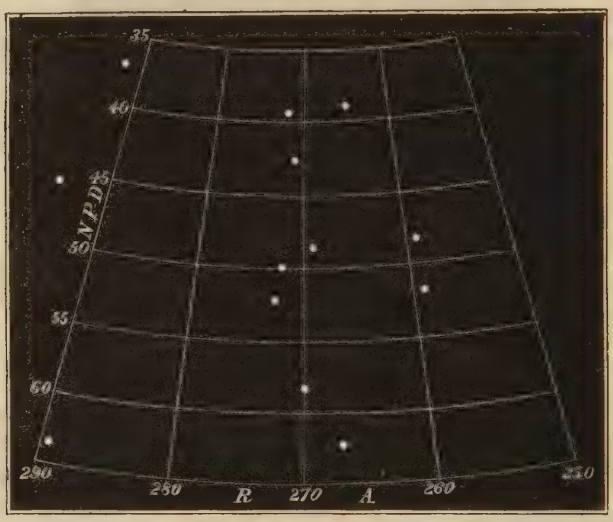


Fig. III.

If we might fairly assume that they all belonged to the Lyrids (the outlying positions being widely erratic members of the same system), then the average of the 14 observations gives a mean of $273°+40°$, which, though evidently about 5° too far N., is in very fair accordance with this radiant as deduced by Mr. Greg at $272°+35°$ (No. 51 of his 1876 Catalogue). But the agreement is purely accidental, for the positions are much too distant to allow them to be justly incorporated into a common centre near the Lyrid meteor apex. There are probably 6 Lyrids amongst them with an average of $271°+35°$, 3 Draconids, $269\frac{1}{2}°+50°$* (= Mr. Greg's No. 47 at $263°+50°$ March 11 -May 31), 2 Herculids, $259°+38\frac{1}{2}°$ (belonging to the special shower near π *Herculis* referred to in my paper on the Meteor

* The fireball of April 6, 1877, had a radiant point at $275°+50°$, confirming this position.

Showers of April 9–12), 3 Cygnids near δ, β, and χ, the two former of which supply many shooting stars at this period.

Some of the alleged stationary meteors, especially those recorded in August, refer to the short bright streaks left in very foreshortened paths, and thus the positions given on the diagrams are somewhat scattered and erratic, but in the case of the Perseids (Fig. II.) there is no doubt that they are all members of that stream. Evidently in very rare cases only would a meteor be seen absolutely at rest like a star or planet, and the number of observations of fixed meteors must be extremely small as compared with those of meteors having paths of about $\frac{1}{2}°$ or 1°, and it is certain that a large proportion of the latter in which the motion escapes detection, must be mistaken for stationary meteors and described as such in Catalogues. Moreover the form of apparition of such objects renders them difficult of detection, unless they are very brilliant, or the observer chances to have his gaze directed towards the place of appearance. Ordinary meteors, by their motion amongst the stars, attract the eye directly, but the smaller class of fixed meteors are very liable to elude detection, especially when visible in a region of bright stars.

A stationary meteor will sometimes appear in a point of the sky from whence no other meteors are directed on the same night. Such an observation acquires additional value from the fact that it affords exact evidence of a very feeble shower, and one of which the radiant could only be derived from long observation. Active showers are readily ascertained from the backward intersection of the usual angular meteors; but attenuated systems will long avoid discovery, as they may only give a solitary member during a whole night's watch. Too much value should not, however, be given to extremely short or stationary meteors when close on the horizon, for the effects of perspective and atmospheric refraction on meteors falling vertically at very low altitudes are such as to cause an extreme contraction of the apparent paths.

The list includes a large number of stationary meteors for April 19–23, July 26–31, and August 8–13, and it might be inferred that at these special epochs there is an actual preponderance of such objects. The fact is, however, that at each of these periods the sky has been watched with unusual diligence, and amongst the multitude of meteors recorded, the number observed to be stationary is considerably in excess of those noted at other seasons, when the aggregate extent of observation has been far less. In order to determine the relative monthly proportion of meteors of all kinds registered by different observers, I recently summarised the results given in twelve Catalogues, which comprise 59,086 meteors, and the following numbers were derived:—

January	2419 ↓s	July	7369 ↓s
February	1609 „	August	23374 „
March	1449 „	September	2897 „
April	4324 „	October	4827 „
May	1133 „	November	5457 „
June	1325 „	December	2903 „

Thus August alone contains as nearly as possible 2-5ths of the total number of observations. The figures for July are also large, and nearly 1-8th of the whole. In August very few records exist for the last half of the month, but in July the bulk of the meteors were seen on the last six nights. The epochs of the Orionids (Oct. 18–20), Leonids (Nov. 13), and Geminids (Dec. 9–12) have each a mass of registered tracks and many stationary meteors. The night of August 10 is the chief one of the year, for more observations have been made on this date than on any other. Apart from the Perseids there is not any specially intense shower, but there are more than 60 distinct meteor radiants visible on that one night alone, and this is but a small minority of the whole number, active and feeble, in action; and thus we may perhaps form some remote idea of the myriads of such streams encountered by the Earth in her annual path.

Close and frequent repetitions in the radiant points of many recent fireballs have been found by Professor Niessl from calculations of their real paths,* and I had myself noticed, both from observation and reduction, many exact agreements in the radiants of successive meteor displays, so that a duration of one, two, and even three months appeared probable in many instances; though that such showers are physically identical is impossible on the assumption that meteor streams pursue parabolic orbits and are necessarily of extremely brief duration, as Lyrids, Leonids, and Andromedes. But these condensed periodical displays are of exceptional character and cannot be held typical of the very numerous and scattered systems which annually recur without any great variation. Feebleness and long duration appear to be their special features as opposed to the transient intensity of the true cometary meteor showers, and it has occurred to me that the present list of stationary meteors might furnish another indication of the long endurance of certain radiant points, for there are many examples of repetition occurring in the list. Thus Nos. 84 and 165, July 28 and Sept. 26, are identical at *δ Draconis*, and there is, singular to say, a very sharply defined radiant here during the period from June 26 to Oct. 31 (127 days). 14 observations by Heis, Greg and Herschel, myself, and others give a radiant at 290°·6+69°·7 (+ 300 meteors), and the positions agree so well that a circle of 5° diameter will include the whole of them

* *Monthly Notices*, vol. xxxix, p. 281.

Now if we are to allow 3 or 4 nights only as the theoretical limiting period of a shower's activity, then this conspicuous shower of Draconids must consist of 30 or 40 different streams directed from the same point near δ *Draconis*! We know that the number of meteor streams must be very great and frequently supplement each other at short intervals so as to give several successive showers of coincident position; but it is very curious that this radiant—and many others—is so exactly and fully exhibited over so long a range of time. Any attempt to disentangle it into a large number of short-lived showers with their periods will defy the most accurate and lengthy observation. Another instance of similar nature occurs in the early part of the year in the case of a shower S. of α *Leonis*, to which belong the stationary meteors, Nos. 16 and 21, at 145°+8°, Feb. 24, and 146°+9°, April 3. This radiant apparently sustains a persistent display from the end of November until the beginning of April, from a centre at 145°+6°. A few other good accordances of stationary meteors may be mentioned. Nos. 191, 208, and 218, Nov. 4, 18, and Dec. 10 have an average position at 133°+47° (ι *Ursæ Majoris*). Nos. 174, 199, and 209, Oct. 19, Nov. 12 and 21, at 125°+40° (*m Lyncis* of Bode). Nos. 29 and 111, April 19, Aug. 10, at 294½°+44° (δ *Cygni*). Nos. 160 and 214, Aug. 30, Nov. 28, at 9°+43° (ν *Andromedæ*), and Nos. 95 and 196, Aug. 4 and Nov. 10, at 213°+43½° (η *Ursæ Majoris*). No. 78, March 10, at 202°+42½° is also near the latter position. There are many other similar instances of repetition apparent in the Table, but they are not often exact, and indeed the whole of them may be explained on the supposition of different showers from the same directions, for it is obvious that many such accordances must naturally arise. Taken in conjunction with observations of the radiants of meteor showers and doubly observed meteors, these stationary meteors will, however, be found of great utility as regards the determination of both the duration and position of many shower centres. But radiant points that are *accurately* derived in the ordinary manner from a number of well observed tracks (including several much foreshortened near the centre) are in my own opinion preferable to those derived from either stationary or doubly observed meteors. So-called stationary meteors are seldom in the exact centre of a radiant point, and in regard to meteors (generally very bright) observed at several stations, the apparition is unexpected and seldom recorded accurately at more than one place by scientific observers thoroughly acquainted with the stars, and when the records are scanty and a little inexact, considerable doubt is at once thrown on the radiant position, which is not often to be relied on to within 5°. On the other hand, systematic watches maintained all night will yield most exact results, and tolerably active showers may have their centres assigned to within 2° of probable error. As observations accumulate of stationary and doubly observed meteors, and of ordinary meteor showers, it will be interesting to compare

the radiant points derived each way. This is already possible in several instances, amongst which the Lyrids Perseids, and Leonids may be mentioned as the best examples, for they also show exact accordances with cometary radiants. We may find a few similar cases occurring amongst the minor showers, one of which, that of the August Andromedes, is specified below:—

	Date.		Radiant.		
Aug.	10	1878	6° $+37^\circ$	shower of 5 meteors	Denning.
Aug.	3–16	1877	10 +38	shower of 16 meteors	Denning.
Aug.	21	1859	10 +39	stationary meteor	Heis.
Aug.	10	1871	7 +32	Doubly obs. meteor	Waller.
Aug.	14	—	$3\frac{1}{2}$ +$38\frac{1}{2}$	Comet II 1780 ♂	A. S. Herschel.

The number of meteors given in the Table is 222, distributed over the year as follows:—

Jan.	10	May	5	Sept.	7
Feb.	6	June	8	Oct.	22
March	4	July	26	Nov.	26
April	33	August	68	Dec.	7

The magnitudes are:—

> 1st	= 1st	= 2nd	= 3rd	= 4th and fainter	??	Total.
29	47	56	37	40	13	222.

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Dec.	Observer.	Place.	Observer's Notes.
			°	°			
1	67 January 2	1	228	+55	Bornitz	Lichtenberg	Leuchtender Punkt.
2	79 January 3	3	137	+ 7	Sawyer	Cambridge, Mass.	Stationary meteor. [*See* No. 5.]
3	77 January 9	>1	164	−15	Denning	Bristol	White. ? if stationary.
4	71 January 12	½	144	−23	Wiener	Athens	[Stationary meteor.]
5	74 January 20	3	136	+ 5	Corder	Writtle	Uncertain in R.A. to a few degrees.
6	52 January 25	1	117	+38	Heis	Aachen	Leuchtender Punkt.
7	70 January 25	3½	22·9	+59·8	Schulhof	Wien	Mitte einer sehr kurzen Bahn.
8	70 January 26	3	10·8	+49·4	Schulhof	Wien	Fast stationäres Meteor. [*See* No. 156.]
9	78 January 28	2	162	+ 3	Sawyer	Cambridge, Mass.	Stationary meteor.
10	78 January 28	4	119	− 6	Sawyer	Cambridge, Mass.	Stationary meteor.
11	57 February 17	2	132	+38	Heis	Münster	Plotzliches Aufleuchten einer Stelle.
12	69 February 17	5	181	− 9	Schmidt	Athens	[Stationary meteor.]
13	68 February 17	?	222	+ 7	Zezioli	Bergamo, Italy	Comparve come brevissimo lampo, impossibile comprenderne la direzione, lasciò bianco 5 secondi.
14	69 February 22	3	217	−41½	Tupman	Mediterranean	Stationary at η *Centauri*.
15	70 February 23	3	33·8	+36·5	Schulhof	Wien	Röthliches, stationäres Meteor.
16	78 February 24	4	145	+ 8	Sawyer	Cambridge, Mass.	Stationary meteor. [*See* No. 21.]
17	78 March 5	>1	189	−11	Backhouse	Sunderland	? Stationary. Seen through gap in clouds.

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Dec.	Observer.	Place.	Observer's Notes.
			°	°			
18	70 March 10	1	202	+42·5	Zezioli	Bergamo	Punto lucido senza movimento sensibile: apparve e sparì come un lampo.
19	65 March 17	3	305	+77	Herschel	Hawkhurst	Almost stationary at *κ Cephei*.
20	63 March 18	1	208·2	+33·4	Crumplen	London	No path. Stationary. 1 second.
21	72 April 3	2	146	+ 9	Zona	Caltanisetta, Italy	Impiegò un secondo nel corso.
22	53 April 5	1	37·5	+53	Heis	Münster	Momentanes Aufblitzen.
23	70 April 5	2	237·0	+ 4·3	Palisa	Troppau	Sehr kurze Bahn. Fast stationär.
24	74 April 6	2	206	−18	Wiener	Athens	[Stationary meteor.]
25	79 April 11	6	75	+45·5	Cornish	Debenham, Suffolk	Stationary meteor. 1½ second.
26	50 April 13	1	251	+74	Heis	Aachen	Heller Lichtpunkt.
27	70 April 19	1	270·1	+31·4	Schulhof	Wien	Fast stationäres Meteor. [Lyrid.]
28	70 April 19	1	258·9	+41·4	Schulhof	Wien	Stationäres Meteor. Dauer 2 seconds. [Herculid.]
29	73 April 19	1	295	+44	Clark	Street	Slight cloud, 1½ sec. Stationary.
30	70 April 19	2	272·1	+50·7	Palisa	Troppau	Stationäres Meteor. [Draconid.]
31	70 April 19	2	289·4	+26·4	Palisa	Troppau	Stationäres Meteor.
32	74 April 19	4	278·8	−28·9	Palisa	Pola	Mitte kurzer Bahn.
33	67 April 20	3	265	+51	Bornitz	Lichtenberg	Leuchtender Punkt. [Draconid.]
34	70 April 20	1	266·7	+27·7	Littrow	Wien	Stationäres Meteor.
35	70 April 20	2	20·6	+55·6	Oppolzer	Wien	Mitte sehr kurzer Bahn. [*See* Nos. 7 and 110.]
36	70 April 20	3	292·7	+52·3	Oppolzer	Wien	Mitte sehr kurzer Bahn.

37	74	April 20	4	223·4 − 5·8	Schulhof	Wien	Stationäres Meteor.
38	74	April 20	1	245 + 11	Clark	Heidelberg	Almost stationary. Path ½° to 245¼° + 11¼°.
39	70	April 21	2	225 + 69	Oppolzer	Wien	Fast stationäres Meteor.
40	70	April 21	8	251·9 + 14·7	Oppolzer	Wien	Mitte einer sehr kurzen, im Kometensucher gesehenen Bahn.
41	70	April 21	3	175·8 + 19·3	Littrow	Wien	Stationäres Meteor.
42	70	April 21	4	272·8 + 40·1	Palisa	Troppau	Stationäres Meteor. [Lyrid.]
43	74	April 21	4	258·9 + 38·1	Palisa	Pola	Stationäres Meteor. [Herculid.]
44	74	April 21	4	271·1 + 47·3	Felgel	Brünn	Fast ganz stationäres Meteor.
45	70	April 22		218·0 + 8·4	Littrow	Wien	Fast stationäres Meteor. Im Kometensucher geschenes.
46	70	April 22	6	269·4 + 41·2	Littrow	Wien	Mitte einer sehr kurzen Bahn. [Lyrid.]
47	74	April 22	3	260·4 + 59·3	Palisa	Pola	Stationäres Meteor.
48	74	April 22	4	248·8 + 6·1	Palisa	Pola	Fast stationär.
49	70	April 23	1½	199·8 + 69·8	Littrow	Wien	Stationäres Meteor.
50	70	April 23	2½	262·4 + 32·3	Palisa	Troppau	Stationäres Meteor. [Lyrid.]
51	70	April 23	4½	273·4 + 37·3	Palisa	Troppau	Stationäre Meteor. [Lyrid.]
52	70	April 23	> 1	218 − 3	Zezioli	Bergamo	Aparve e sparì nello stesso sito.
53	68	April 28	1	194 + 12	Greg	Manchester	Nearly stationary at ϵ *Virginis*.
54	72	May 9	2	163 + 58	Franzi	Montcalieri	[At β *Ursæ Majoris*.]
55	72	May 15		191 + 47	Gerardini	Lodi, Italy	Stella immobile nel punto assignato.
56	77	May 15	2	256 + 5	Denning	Bristol	White; transient; stationary.

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Dec.	Observer.	Place.	Observer's Notes.
			°	°			
57	68 May 26	1	107	+67·5	Zezioli	Bergamo	Nel punto qui indicato apparve una luce maggiore che di 1ª grandezza senza direzione alcuna.
58	58 May 31	⅓ = ♄	285	+34	J. F. Herschel	Hawkhurst	Path of light its own size, 2 secs., same alt. as β and same azimuth as α *Lyræ*.
59	57 June 1	2 × ♃	303	−14	Abbott	Hobart Town	Stationary between α and β *Capricorni*.
60	69 June 4	4½	331·0	+52·9	Rosner	Wien	Mitte sehr kurzer Bahn.
61	69 June 4	2	3·7	+67·0	Palisa	Wien	Mitte sehr kurzer Bahn. [*See* No. 82.]
62	77 June 4	1	323	+11	Esdaile	E. Grinstead, Sussex	A stationary fireball.
63	69 June 9	4	317·4	+45·7	Oppolzer	Wien	Mitte sehr kurzer Bahn. [Cygnid.]
64	69 June 9	4	291·3	+26·4	Rosner	Wien	Mitte sehr kurzer Bahn.
65	70 June 17	2	273	−28	Wiener	Athens	[Stationary meteor.]
66	70 June 28	1	290	−17	Wiener	Athens	[Stationary meteor. *See* No. 78.]
67	72 July 3	2	215	+16	Gerardini	Lodi	[Near *Arcturus*.]
68	67 July 4	6	255	+63	Zezioli	Bergamo	[Six stars with short paths appeared here at small intervals.]
69	62 July 21	2	8	+20	Bornitz	Lichtenberg	Leuchtender Punkt.
70	78 July 21	3	76	+54	Denning	Bristol	Almost stationary. [Aurigid.]
71	54 July 25	5	344	+42·5	Winnecke	Göttingen	Leuchtender Punkt.
72	67 July 26	1	244	+43	Zezioli	Bergamo	Più chiara di Wega, come lampo apparve e scomparve nel medesimo punto.

73	70	July 26	2	350·0 + 47·1	Palisa	Wien	Fast ganz stationäres Meteor.
74	70	July 26	2	359·4 + 48·6	Strasser	Kremsmünster	Mitte sehr kurzer Bahn.
75	70	July 26		140·7 + 78·7	Strasser	Kremsmünster	Mitte sehr kurzer Bahn.
76	70	July 26	4	308·4 + 4·7	Felgel	Brünn	Mitte der Bahn eines sehr kurzen.
77	70	July 26	3	30·3 + 47·2	Bartel	Brünn	Mitte der sehr kurzen Bahn. [Perseid II.]
78	70	July 26	> 1	296 − 14	Herschel	Hawkhurst	Almost stationary. Moved slightly west.
79	54	July 27	4	37·5 + 48	Winnecke	Göttingen	Sehe man unten nach. [Perseid II.]
80	73	July 27	4	359·5 + 52·2	Nagy	O'gyalla	Stationäres Meteor.
81	76	July 27	3	336·4 + 66	Konkoly	O'gyalla	[Stationary meteor.]
82	51	July 28	1	12 + 76	Billerbeck	Rastenburg	[Stationary meteor.]
83	65	July 28	2	284 + 70	Herschel	Hawkhurst	Very short. Nearly stationary.
84	65	July 28	2	290 + 67·5	Herschel	Hawkhurst	Stationary close to δ *Draconis*.
85	78	July 28	3	38 + 32	Denning	Bristol	Very short. Streak 3 secs.
86	78	July 28	4	341 + 51	Corder	Writtle	Path ½° to 342° + 51°. Lacertid.
87	78	July 29	3	304½ + 23	Corder	Writtle	Path ½° to 305° + 22¾°.
88	70	July 29		351 + 18	Palisa	Wien	Stationäres Meteor.
89	75	July 31	4	295·3 + 52·2		O'gyalla	Path ¼° to 295°·1 + 52°·0.
90	56	July 31	♀	336 − 6	Heis	Münster	Leuchtender Punkt, röthlich. [*See* No. 92.]
91	56	July 31	2	38 + 38	Heis	Münster	Leuchtender Punkt.
92	59	July 31	3	341 − 8½	Schmidt	Athens	[Stationary meteor.]

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Position. Dec.	Observer.	Place.	Observer's Notes.
			°	°			
93	78 August 2	2	32	+55	Denning	Bristol	Stationary at χ *Persei*. 3 secs.
94	67 August 2	6	40	+45	Heis	Münster	Leuchtender Punkt.
95	61 August 4	4	215	+42	Heis	Münster	Hell leuchtend blau ohne Bahnstrecke.
96	64 August 5	♀	44	+57	Heis	Münster	Leuchtender Punkt. [Perseid.]
97	69 August 5	2	100·1	+66·9	Felgel	Wien	Mitte einer sehr kurzen Bahn.
98	72 August 5	3	33	+33	Lorenzoni	Padova	Un punto.
99	70 August 6	♀	42	+75	Greg	Manchester	Stationary meteor. 4 secs. [*See* No. 112.]
100	71 August 8	1	38	+34·5	Waller	York	Quite stationary. Luminous cloud for $1\frac{1}{2}$ sec. over $\frac{1}{4}°$. [*See* No. 85.]
101	78 August 8	4	353	+42	Corder	Writtle	Stationary meteor. [*See* No. 73.]
102	64 August 8	1	59	+70	Heis	Münster	Leuchtender Punkt. [*See* No. 119.]
103	76 August 8	3	35	+57	Denning	Bristol	Meteoric luminosity $1\frac{1}{2}$ sec. [Perseid.]
104	61 August 8	>1	117	+64	Airy	Ipswich	A stationary flash.
105	69 August 9	1	73	+61	Herschel	Hawkhurst	Very short path $\frac{1}{2}$ sec. A sudden flash. [Approximate.]
106	76 August 9		347	+26	Backhouse	Sunderland	Rather uncertain. [Pegasid I.]
107	72 August 9	1	39	+60	Clark	York	Almost perfectly stationary. [Perseid.]
107*a*	78 August 9	3	44	$+56\frac{1}{2}$	Sawyer	Cambridge, Mass.	Stationary. Accurate. [Perseid.]
108	50 August 9	1	43	+53	Heis	Aachen	Leuchtender Punkt. [Perseid.]
109	66 August 9	2	27	+21	Heis	Münster	Leuchtender Punkt.
110	50 August 10	1	25	+58	Heis	Aachen	Sehr heller Lichtpunkt. [*See* Nos. 7, 35, and 186.]

111	73	August 10	1	294	+44	Heis	Münster	Leuchtender Punkt.
112	63	August 10	2	51	+75	Heis	Münster	Leuchtender Punkt. [*See* Nos. 99 and 102.]
113	64	August 10	3	40	+55	Heis	Münster	Leuchtender Punkt. [Perseid.]
114	72	August 10	3	48·8	+62·0	Schulhof	Wien	Stationäres Meteor. [Perseid.]
115	72	August 10	2	216·5	+38·1	Schulhof	Wien	Blos Anfangspunkt beobachtet.
116	72	August 10	4	43·1	+1·8	Schulhof	Wien	Stationäres Meteor.
117	72	August 10	3	48	+49	Maggi	Volpeglino, Italy	Si spegne senza far cammino. [Perseid.]
118	72	August 10	1	76	+46	Maggi	Volpeglino	Si spegne senza far cammino. [Aurigid, *see* No. 137.]
119	74	August 10	5	55·1	+69·6	Konkoly	O'gyalla	[Stationary meteor. *See* No. 102.]
120	77	August 10	4	38	+58·5	Denning	Bristol	A stationary Perseid.
121	72	August 10	–	51	+61·5	Serpieri	Urbino	[A stationary Perseid.]
122	77	August 10	2	63	+46	Johnson	Crediton	White; almost stationary; below μ *Persei*.
123	69	August 10	1	337	+78	Backhouse	Sunderland	Stationary at 28 *Cephei*; yellow.
124	70	August 10	2	32	+56	Backhouse	Sunderland	Stationary. [Perseid.]
125	61	August 10	2	258	+15	Crumplen	London	Stationary, 1° E. of α *Herculis*.
126	68	August 10		18	+32	Lucas	Oxford	Below β *Andromedæ*; no motion.
127	68	August 10	>1	32	+56	Lowe	Beeston, Notts	Appeared and disappeared without motion; 40′ in diameter.
127*a*	74	August 10	3	45	+57	Clark	Birmingham	Stationary; white. Train $1\frac{1}{2}$ sec. [Perseid.]
128	78	August 10	3	47	+58	Corder	Writtle	Stationary. [Perseid.]

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Dec.	Observer.	Place.	Observer's Notes.
129	76 August 10	♃	49½°	+58°	Tupman	St. Moritz	Almost stationary; slight motion. [Perseid.]
130	72 August 10	3	49°	+55°	Serpieri	Urbino	Path ½° to 49½° + 54°·7. [Perseid.]
131	74 August 10	2	51½°	+51¾°	Clark	Birmingham	Path ½° to 52° + 51½°. [Perseid.]
132	77 August 10		30°·1	+56°·1	Schrader	O'gyalla	Path ¾° to 29°·5 + 55°·5. [Perseid.]
133	69 August 11	3	48½°	+54½°	Backhouse	Sunderland	Very short; direction imperceptible. [Perseid.]
134	77 August 11	2	52°	+52°	Johnson	Crediton	Nearly stationary. [Perseid.]
135	72 August 11	3½	279°·8	+41°·3	Schulhof	Wien	Mitte einer sehr kurzen Bahn.
136	69 August 11		47°·5	+59°·3	Tupman	Mediterranean	Stationary Perseid.
137	63 August 12	2	80°	+43	Heis	Münster	Aufleuchtend. [Aurigid.]
138	72 August 12	2	211°·2	+34°·5	Schulhof	Wien	Stationäres Meteor; orange färbiges.
139	69 August 12	1	3°	−9	Backhouse	Sunderland	At *ι Ceti*; stationary; yellow.
140	69 August 12	4	96°·9	+55°·3	Rosner	Simmering	Path ½° to 98°·1 + 55°·3.
141	76 August 12	2	32½°	+58¾°	Clark	York	Centre of path of only ⅛°. [Perseid].
142	67 August 13	♀	314°	−8	Heis	Münster	Ohne Bewegung aufblitzend.
143	69 August 13	2	201°·3	+55°·3	Oppolzer	Wien	Mitte einer sehr kurzen Bahn.
144	69 August 13	5½	299°·4	+10°·2	Littrow	Wien	Mitte einer sehr kurzen Bahn. [Aquilid.]
145	69 August 13	2	48°·7	+61°·5	Felgel	Wien	Stationäres Meteor. [Perseid.]
146	68 August 14	1	144°	+55	Greg	Whitby, York	Nearly stationary; 1 sec.
147	68 August 15	1	194°	+44	Greg	Whitby, York	Nearly stationary. Path 1° in ¾ sec.

148	57	August 16	2	337 + 9	Heis	Münster	Aufblitzend.
149	65	August 16	♀	272 −45·5	Wiener	Athens	[Stationary bolide.]
150	65	August 16	♀	338 −21·5	Wiener	Athens	[Stationary bolide.]
151	49	August 18	2	320 +63	Heis	Münster	Leuchtender Punkt der plötzlich verschwand.
152	59	August 21	2	10 +39	Heis	Münster	Punkt. [*Andromedee.*]
153	70	August 22	1	308·2 −20·3	Holetschek	Wien	Stationäres Meteor.
154	76	August 22	4	321½ + 9	Backhouse	Sunderland	Duration 0·5 sec. [*See* Nos. 62 & 162].
155	70	August 22	3	55·1 +26·6	Borutsky	Schram	Path ½° to 55°·8 + 26°·6.
156	71	August 25	2	9 +49½	Tupman	Mediterranean	Stationary meteor.
157	72	August 25	☽	10 + 7	Maggi	Volpeglino	[Stationary bolide.]
158	78	August 26	3	264 +12	Backhouse	Sunderland	Stationary; if motion, towards *α Ophiuchi* and about ½°.
159	65	August 27	♃	260 −41·5	Wiener	Athens	[Stationary bolide.]
160	73	August 30	9	8½ +41½	Backhouse	Sunderland	Seen in Equatoreal, power 38; path 12′ or 13′.
161	68	September 12	2	90 +70	Greg	Pitlochin	Very short; towards *Ursa Major.*
162	64	September 23	3	324 +12½	Herschel	Hawkhurst	Stationary; 1 second; white.
163	51	September 25	1	45 +40	Heis	Aachen	Leuchtender Punkt.
164	50	September 26	1	223 +27	Heis	Aachen	Leuchtender Punkt.
165	51	September 26	☽	292 +68	Heis	Aachen	Leuchtender Punkt; Feuerkugel.
166	51	September 27	1	10 −17	Heis	Aachen	Hell leuchtender Punkt.
167	78	September 29	1	15 + 3	Sawyer	Cambridge, Mass.	Orange; 1 sec.; approximate.

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Dec.	Observer.	Place.	Observer's Notes.
			°	°			
168	78 October 1	4	8	+15	Sawyer	Cambridge, Mass.	Stationary; accurate.
169	77 October 2	2	302	+ 1·5	Backhouse	Sunderland	Orange; like a star or planet.
170	77 October 3	4	68	+33	Corder	Writtle	Stationary.
171	77 October 6	3	25	+18·5	Corder	Writtle	Stationary.
172	77 October 17	2	141	+28	Denning	Bristol	A stationary flash.
173	73 October 18	1·5	88·8	+76·7		Wien	[?? if stationary.]
174	74 October 19	5	128	+40	Backhouse	Sunderland	Stationary. [*See* Nos. 199 & 209.]
175	67 October 20	2	319	+19	Schmidt	Athens	[Stationary meteor.]
176	64 October 20	3	90	+70	Herschel	Hawkhurst	Nearly stationary; light patch 2 secs.
177	64 October 20	2	285	+63	Herschel	Hawkhurst	A stationary meteor. [*See* No. 198.]
178	78 October 20	2	355	+12·5	Sawyer	Cambridge, Mass.	Stationary 1 sec.; accurate.
179	78 October 21	4	39	−18	Sawyer	Cambridge „	Stationary; approximate.
180	78 October 22	1	24	− 1	Sawyer	Cambridge „	Stationary 1 sec.; seen through haze.
181	54 October 22	♀	272	+44	Heis	Münster	Leuchtender Punkt.
182	72 October 22	2	334	+61	Nagy	O'gyalla	Stationäres Meteor; bläulich weisses; durch 4 sec. sichtbares.
183	49 October 24	1	55	+45	Heis	Aachen	Leuchtender Punkt; röthlich; schw. 3 secund. sichtbar.
184	78 October 25	1	325	+38	Corder	Writtle	Stationary.
185	48 October 26	1	280	+24	Schmidt	Bonn	[Stationary meteor.]
186	69 October 27	2	17	+59	Clark	York	Path $\frac{1}{2}$° towards *Polaris*. $\frac{1}{2}$ sec.

187	78	October 29	2	31	+13·5	Sawyer	Cambridge, Mass.	Stationary; accurate.
188	67	October 29	½ = ☽	74	+62	Haly and Miller	Glasgow	Short curved path; 1 second. Approximate.
189	72	October 30		29	− 3	Backhouse	Sunderland	Uncertain observation. [*See* No. 180.]
190	59	November 2	1	231	+71	Lowe	Beeston, Notts	Four rapid flashes at same point. 20° below Polar Star. Approximate.
191	77	November 4	5	137	+47	Corder	Writtle	Stationary meteor. [*See* Nos. 208 & 218.]
192	77	November 7	1	338	−15	Johnson	Crediton	1° W. of τ *Aquarii*; no motion.
193	64	November 7	1	141	−11	Herschel	Hawkhurst	Stationary. Appeared to oscillate.
194	77	November 7	3	144	+42	Denning	Bristol	Stationary; light cloud; 3 secs.
195	63	November 9	♀	9	−18	Heis	Münster	Leuchtender Punkt.
196	49	November 10	1	211	+45	Schmidt	Bonn	[Stationary meteor. *See* No. 95.]
197	49	November 11	4	222	+64	Schmidt	Bonn	[Stationary meteor.]
198	49	November 12	3	287·5	+61·5	Schmidt	Bonn	[Stationary meteor. *See* No. 177.]
199	77	November 12	1	126	+40	Denning	Bristol	Stationary; small luminous cloud.
200	52	November 13	1	145	+61	Billerbeck	Rastenburg	[Stationary meteor.]
201	59	November 13	2	58	+12	Heis	Münster	Leuchtender Punkt. [*See* No. 211.]
202	66	November 13		149¾	+23¾	Backhouse	Sunderland	At ½ ($\mu-\gamma$ *Leonis*). Leonid.
203	70	November 13	2	150	+22¼	Backhouse	Sunderland	Stationary like a fixed star. Leonid.
204	49	November 13	1	95	+24	Rath	Coln	Path ½° to 95° + 24½°.
205	66	November 14	♀	148	+25	Wood	Birmingham	Stationary body; 4 secs. Leonid.
206	66	November 14	> 1	100	−17	Heinecken	Sidmouth	Stationary over *Sirius*.
207	75	November 15	1	158	+40	Nash	Greenwich	Almost stationary; path ½°.

No.	Year (1800+) and Date.	Mag.	Position. R.A.	Dec.	Observer.	Place.	Observer's Notes.
			°	°			
208	65 November 18	>1	132	+49	Hudson	Cambridge	No path; near ι *Ursæ Majoris*.
209	49 November 21	2	120	+40	Heis	Aachen	Einzelner Lichtpunkt.
210	68 November 21	2	75	−10	Clark	Ackworth	Short path; $1\frac{1}{2}$° W. of *Rigel*. A flash.
211	78 November 23	4	54	+ 9	Sawyer	Cambridge, Mass.	Stationary meteor. [*See* No. 201.]
212	72 November 27	2	29	+46	Denning	Bristol	Stationary; *Andromedee*.
213	72 November 27	2	26	$+45\frac{3}{4}$	Backhouse	Sunderland	Stationary; *Andromedee*.
214	77 November 28	4	9	+43	Corder	Writtle	Stationary meteor.
215	70 November 29	3	67·5	−18·5	Palisa	Wien	Mitte einer sehr kurzen Bahn.
216	71 December 1		295	−12	Sawyer	Cambridge, Mass.	Stationary; approximate.
217	77 December 8	3	14	+29	Corder	Writtle	Stationary meteor.
218	74 December 10	>1	130	+46	Gruey	Toulouse	Stationary meteor.
219	69 December 11	1	112·7	+35·9	Felgel	Brünn	Beinahe stationär; eingestellt mitte der Bahn.
220	69 December 11	3	120·7	+49·2	Bartel	Brünn	
221	69 December 11	3	82·9	+22·9	Bartel	Brünn	No. 221 belongs to the Taurids II.
222	54 December 28	2	179	+13	Heis	Münster	Leuchtender Punkt.

Two Short and Easy Methods for correcting Lunar Distances.

By J. J. Åstrand, Director of the Bergen Observatory.

(*Communicated by Lord Lindsay.*)

The following methods for correcting lunar distances are equal in accuracy to those of Mendoza y Rios and Witchell, but considerably shorter and easier. As well as these methods, they are based on the well-known expression for the true distance developed by help of Taylor's Theorem, viz.—

(1) $d = d' - \Delta h \cos v + \Delta H \cos V +$ small corrections of the second and higher orders,

and where

d the true distance,
d' the apparent distance,
v the angle at the Moon's apparent place,
V the angle at the other object's apparent place,
Δh the correction for the Moon's altitude,
ΔH the correction for other object's altitude.

By transforming (1) we have

$$d = d' - \Delta h\,(1 - 2\sin^2 \tfrac{1}{2}v) + \Delta H\,(1 - 2\sin^2 \tfrac{1}{2}V) + \ldots\ ,$$

or

$$(2) \qquad d = d' - (\Delta h - \Delta H) + 2\,(\Delta h \sin^2 \tfrac{1}{2}v - \Delta H \sin^2 \tfrac{1}{2}V) + \ldots\ .$$

Now

$$\sin^2 \tfrac{1}{2}v = \frac{\cos \tfrac{1}{2}s \sin (\tfrac{1}{2}s - H')}{\sin d' \cos h'}$$

$$= \frac{\cos \tfrac{1}{2}s \sin (\tfrac{1}{2}s - H') \cos (\tfrac{1}{2}s - d')}{\sin d' \cos h' \cos (\tfrac{1}{2}s - d')},$$

where

h' the Moon's apparent altitude,
H' the other object's apparent altitude, and
$s = h' + H' + d'$.

But

$$\frac{\sin (\tfrac{1}{2}s - H')}{\cos h' \cos (\tfrac{1}{2}s - d')} = \tan h' - \tan (\tfrac{1}{2}s - d'),$$

and

$$\frac{\sin d'}{\cos \tfrac{1}{2}s \cos (\tfrac{1}{2}s - d')} = \tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d').$$

Consequently

$$\sin^2 \tfrac{1}{2}v = \frac{\tan h' - \tan (\tfrac{1}{2}s - d')}{\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d')}. \tag{3}$$

In the same manner

$$\sin^2 \tfrac{1}{2}\mathrm{V} = \frac{\tan \mathrm{H}' - \tan (\tfrac{1}{2}s - d')}{\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d')}. \tag{4}$$

Substituting these values of $\sin^2 \frac{1}{2}v$ and $\sin^2 \frac{1}{2}\mathrm{V}$ in (2),

$$d = d' - (\Delta h - \Delta \mathrm{H}) + \frac{[\tan h' - \tan (\tfrac{1}{2}s - d')]\ \Delta h - [\tan \mathrm{H}' - \tan (\tfrac{1}{2}s - d')]\ \Delta \mathrm{H}}{\tfrac{1}{2}[\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d')]} + \ldots \tag{5}$$

or, putting

$$\tan h' - \tan (\tfrac{1}{2}s - d') = \mathrm{A},$$
$$\tan \mathrm{H}' - \tan (\tfrac{1}{2}s - d') = \mathrm{B},$$
$$\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d') = \mathrm{C},$$

this becomes

$$d = d' - (\Delta h - \Delta \mathrm{H}) + \frac{\mathrm{A}\Delta h - \mathrm{B}\Delta \mathrm{H}}{\tfrac{1}{2}\mathrm{C}} + \ldots \tag{6}$$

When (1) is transformed in the form

$$d = d' - \Delta h\ (2\cos^2 \tfrac{1}{2}v - 1) + \Delta \mathrm{H}\ (2\cos^2 \tfrac{1}{2}\mathrm{V} - 1) + \ldots\ ,$$

or

$$d = d' + (\Delta h - \Delta \mathrm{H}) - 2\ (\Delta h \cos^2 \tfrac{1}{2}v - \Delta \mathrm{H} \cos^2 \tfrac{1}{2}\mathrm{V}) + \ldots\ , \tag{7}$$

an analogous deduction gives

$$\cos^2 \tfrac{1}{2}v = \frac{\tan \tfrac{1}{2}s - \tan h'}{\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d')}, \tag{8}$$

$$\cos^2 \tfrac{1}{2}\mathrm{V} = \frac{\tan \tfrac{1}{2}s - \tan \mathrm{H}'}{\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d')}. \tag{9}$$

Consequently,

$$d = d' + (\Delta h - \Delta \mathrm{H}) - \frac{(\tan \tfrac{1}{2}s - \tan h')\ \Delta h - (\tan \tfrac{1}{2}s - \tan \mathrm{H}')\ \Delta \mathrm{H}}{\tfrac{1}{2}[\tan \tfrac{1}{2}s - \tan (\tfrac{1}{2}s - d')]} + \ldots\ ; \tag{10}$$

or, putting

$$\tan \tfrac{1}{2}s - \tan h' = \mathrm{A}',$$
$$\tan \tfrac{1}{2}s - \tan \mathrm{H}' = \mathrm{B}',$$

this is

$$d = d' + (\Delta h - \Delta \mathrm{H}) - \frac{\mathrm{A}'\Delta h - \mathrm{B}'\Delta \mathrm{H}}{\tfrac{1}{2}\mathrm{C}} + \ldots\ . \tag{11}$$

Since $\Delta d = d - d'$ is always $< 1°$, it is, in most cases, sufficiently correct to take the arcs to the nearest minute, and to perform the calculation with four-figure natural tangents.

When greater accuracy is required, especially when the altitudes are low and the distance small, the corrections of the second order (first deduced by Lexell*) may be taken into account, viz.

$$(12) \qquad \begin{cases} \frac{1}{2}(\Delta h^2 - \Delta d^2) \sin 1'' \cot d' \\ + \dfrac{\cos(h' + \mathrm{H}') \cos(h' - \mathrm{H}')}{\cos h' \cos \mathrm{H}'} \Delta h \Delta \mathrm{H} \sin 1'' \operatorname{cosec} d' \\ + \tan h' \tan \mathrm{H}' \Delta h \Delta \mathrm{H} \sin 1'' \cot d' \\ + \frac{1}{2} \Delta \mathrm{H}^2 \sin 1'' \cot d'. \end{cases}$$

The first of these corrections, commonly called "the third correction," is contained in Chauvenet's *Spherical and Practical Astronomy*, ii. pp. 620, 621, as well as in almost all collections of nautical tables, and is thence easily applied. The other three corrections are, in low latitudes, generally very small, but in high latitudes cases are common in which the sum of these corrections is $> 10''$.

According to Legendre† the sum of all four corrections of the second order can be taken into account when Δd is recalculated with $d' + \frac{1}{2}\Delta d$, $h' + \frac{1}{2}\Delta h$, and $\mathrm{H}' - \frac{1}{2}\Delta \mathrm{H}$, viz. the given variables augmented with their half variations.

Example:

$d' = 51°\ 24'\ 45''$, $h' = 58°\ 56'$, $\mathrm{H}' = 62°\ 45'$, $\Delta h = 30'\ 4'' = 1804''$, $\Delta \mathrm{H} = 26''$.

By (6).

° ′				
51 25				
58 56	1·6599			
62 45		1·9416		
173 6				
86 33				16·5874
35 8	0·7037	0·7037		0·7037
	0·9562	1·2379		15·8837
	1804	26		
			° ′ ″	
			51 24 45	

$$\frac{1725 - 32}{7{\cdot}942} = 213'' = +\ 3\ 33$$

$$-\ 29\ 38$$

$$d = 50\ 58\ 40$$

* *Act. Acad. Petr. p. A.* 1777. Petropoli, 1780, p. 348.

† *Mém. de l'Institut*, t. iv., 1805; and Delambre's *Astronomie*, t. iii., 1814, p. 625.

By (11).

° ′			
51 25			
58 56	1·6599		
62 45		1·9416	
173 6			
86 33	16·5874	16·5874	16·5874
35 8			0·7037
	14·9275	14·6485	15·8837
	1804	26	

$$-\frac{26929-381}{7\cdot942} = -3343'' = -\ 55'\ 43''$$

	° ′ ″
	51 24 45
+	29 38
d =	50 58 40

The "third correction" is here only 1″·6, and the other corrections are evanescent.

The following formulæ are of the same class as (3), (4), (8), and (9):

$$\cos A = \frac{\cot(\frac{1}{2}s-b)+\cot\frac{1}{2}s-2\cot c}{\cot(\frac{1}{2}s-b)-\cot\frac{1}{2}s} = \frac{\cot(\frac{1}{2}s-c)+\cot\frac{1}{2}s-2\cot b}{\cot(\frac{1}{2}s-c)-\cot\frac{1}{2}s},$$

$$\text{vers sin } A = 2.\frac{\cot b-\cot\frac{1}{2}s}{\cot(\frac{1}{2}s-c)-\cot\frac{1}{2}s} = 2.\frac{\cot c-\cot\frac{1}{2}s}{\cot(\frac{1}{2}s-b)-\cot\frac{1}{2}s},$$

$$\sin\tfrac{1}{2}A = \sqrt{\frac{\cot b-\cot\frac{1}{2}s}{\cot(\frac{1}{2}s-c)-\cot\frac{1}{2}s}} = \sqrt{\frac{\cot c-\cot\frac{1}{2}s}{\cot(\frac{1}{2}s-b)-\cot\frac{1}{2}s}},$$

$$\cos\tfrac{1}{2}A = \sqrt{\frac{\cot(\frac{1}{2}s-b)-\cot c}{\cot(\frac{1}{2}s-b)-\cot\frac{1}{2}s}} = \sqrt{\frac{\cot(\frac{1}{2}s-c)-\cot b}{\cot(\frac{1}{2}s-c)-\cot\frac{1}{2}s}},$$

$$\tan\tfrac{1}{2}A = \sqrt{\frac{\cot b-\cot\frac{1}{2}s}{\cot(\frac{1}{2}s-c)-\cot b}} = \sqrt{\frac{\cot c-\cot\frac{1}{2}s}{\cot(\frac{1}{2}s-b)-\cot c}},$$

where A is one of the angles of a spherical triangle, b, c the adjacent sides, and s the sum of the sides.

On the Spectrum of Brorsen's Comet, observed at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

Brorsen's Comet was examined with the half-prism spectroscope mounted on the Great Equatoreal on April 17, and subsequent evenings whenever the state of the sky allowed. The dispersion used was that of one compound "half-prism," equivalent to four flint prisms of 60° (20° from A to H) with a power of 12 on the viewing telescope.

The spectrum consists of the three usual cometary bands, corresponding to the three principal bands of the second spectrum of carbon, and does not present the anomalous appearance found by Dr. Huggins in 1868. The bands were compared on several evenings with those shown by a vacuum tube containing vapour of alcohol at a pressure of 1·2 m.m., and the coincidence appeared sensibly perfect.

The position of the brightest comet-band (in the green) was measured with Hilger's bright line micrometer on two evenings, April 19 and 28, by Mr. Maunder; on other occasions it was compared with the corresponding carbon-band indirectly by means of a movable bar in the eyepiece, 30 tenth-metres broad. The following are the results of the micrometer readings for the less refrangible edge of the comet-band referred to the centre of the brightest portion of the carbon-band, which (with a narrow slit) is less than 5 tenth-metres broad:—

1879.	Comet-band.	Wave-length inferred.	Width of slit. in.
April 19	0·5 tenth-metres to blue	5190	0·009 = 16 tenth-metres.
28	4·5 „ to red	5191	0·013 = 24 „

The wave-length of the less refrangible edge of the carbon-band (alcohol vapour in a vacuum tube) has been taken at 5198·3 tenth-metres. As it was not found practicable to use a narrower slit, there is probably an uncertainty of several tenth-metres in the position of the comet-band, but it appears from these observations that it coincides approximately with the band in the second spectrum of carbon (vacuum tube) at 5198, and not with that in the first spectrum (blue flame of Bunsen burner) at 5165. On April 17 several comparisons were made by Mr. Christie, by bringing up a movable bar from the blue end of the spectrum so as just not to hide the bright edge of the comet-band, and in every case the coincidence of the less refrangible edges of the comet- and alcohol-bands appeared sensibly perfect. In these observations the slit was of such a width that the bright line, with which the alcohol-band commences, had a breadth of about 30 tenth-metres. The principal comet-band extended about $\frac{2}{3}$ of the way towards F, to about wave-length 5,000, its blue end appearing to coincide approximately with a faint band of alcohol.

The second comet-band in the yellow was measured on April 28 by Mr. Maunder, and its red edge was found to be 2·4 tenth-metres to the red of the middle of the brightest part of the alcohol-band at 5610. The slit, however, was very wide, viz. $0^{in.}·033$, corresponding to 65 tenth-metres. This measure would place the red edge of the comet-band at 5580, whilst the band in the first spectrum of carbon is at 5635. The more refrangible end of the yellow band appeared to coincide with a well-marked band in the alcohol spectrum. The third comet-band was very faint; it appeared to be in the

neighbourhood of the blue band of alcohol at 4835. The relative brightness of the three bands was estimated thus: Green, 10; Yellow, 3; Blue, ½.

The comet has now decreased considerably in brightness, and its spectrum has become extremely faint. Unfortunately no observations were practicable before April 17, as the Great Equatoreal was in the workmen's hands for alterations to adapt it to more convenient use with the spectroscope.

The observations were made by Mr. Christie and Mr. Maunder.

Royal Observatory, Greenwich,
1879, *May* 9.

Observations of Brorsen's Comet. By Lord Lindsay.

1879, April 12, at $12^h\ 9^m$ S.M.T., the comet was well seen between clouds. It had a raylike tail, which could be traced for about 25′ from the highly condensed nucleus. The coma was obviously elongated at right angles to the direction of the tail, its greatest diameter being about 5′. Clouds prevented further observations.

April 16, $10^h\ 30^m$ S.M.T., tail 10′ long, in position 57°·8 by six measures with powers 122 and 229. No structure could be detected in the nucleus with powers 229 or 312.

April 17, $12^h\ 56^m$ S.M.T., tail 13′ long, in position 51°·9 from three measures with power 122.

The spectrum was observed on April 16, May 2 and 3.

It consisted of three broad bands, the brightest parts of which had the following wave-lengths :—

	m.m.m.
No. 1	547·6
2	515·6
3	469·6

Nos. 2 and 3 were sharply bounded on the less refrangible side, fading off gradually towards the violet. No. 1 was very ill-defined on both sides, and, being without any definite brighter part, its wave-length is very uncertain. Observers, Ralph Copeland and J. G. Lohse.

Dunecht, 1879, *May* 7.

Observations of Brorsen's Comet. By J. Tebbutt, Esq.

On Saturday evening, February 22, at 8 o'clock, I detected a faint nebulous object close to the position assigned to Brorsen's Comet in the Ephemeris of Dr. Schulze in the *Astronomische Nachrichten*, No. 2220. It presented the appearance of

an elliptic nebula, the major axis being nearly coincident with a parallel of declination. Unfortunately the object, was only visible in the fading twilight for about ten minutes, it having disappeared behind the walls of the new Observatory now in course of erection. I saw it again for about an equal interval last evening, and succeeded in obtaining a very imperfect ring comparison with a star of the $5\frac{1}{2}$ mag. identified as B.A.C. 200 or 17 *Ceti*. The star crossed the northern side of the ring, while the comet, unfortunately, only grazed the exterior southern edge. From this rough observation the comet appeared, at $8^h\ 2^m$ local mean time, to be about $3^m{\cdot}3$ east and 11′ south of the star. I had not time to repeat the observation. During the interval between the 22nd and 23rd the comet had moved considerably to the east and north.

I trust to be able to send some useful observations of this body. In the meantime I forward this hurried note, as the Torres Straits mail closes to-morrow at Sydney.

Observatory, Windsor, N.S.W.,
1879, *Feb.* 24.

Observations of Brorsen's Comet. By H. C. Russell, Esq.

By aid of Dr. Schulze's Ephemeris, *Astronomische Nachrichten*, No. 2220, I found the comet on February 24, but it was cloudy, and I could not get a comparison with a star before the clouds hid the comet. The 25th was cloudy; but on the 26th I found the comet as soon as it was dark enough to see it, $7^h\ 40^m$ P.M. It was very faint, about 3 seconds (time) in diameter, with a little central condensation, but no nucleus.

The mean of seven comparisons with B.A.C. 248 gave the following result :—

		h m s	
S.M.T.		7 50	
Comet following star		1 46·71	
		′ ″	
Comet south of star		10 55·19	Not corrected for refraction.
		h m s	
Position therefore of comet	R.A.	0 49 57·64	
		° ′ ″	
	N.P.D.	99 34 45·97	

It has been cloudy every night since until to-night. I saw the comet and obtained a comparison with Weisse No. 223, but it was very difficult, owing to moonlight.

	h m s	
Star and comet, same R.A. at	8 15	S.M.T.
	′ ″	
Comet south of star	5 21·57	

Sydney Observatory,
1879, *March* 6.

Note on Gruithuisen's Lunar Crater "Schroeter."

By John Birmingham, Esq.

(*Communicated by W. H. M. Christie.*)

In view of the discussions about Dr. Klein's lunar crater, it strikes me that an observation of Gruithuisen's *Schroeter* which I made on March 29, 1871, may be worth notice. On that night, with the terminator on *Eratosthenes* and *Plato*, I saw that the formation ended on the south with two large craters joined together in a nearly meridional line. The southern crater at the extreme end was deep, and the other, inside, which I will call No. 2, was very shallow, but rather wider than the former. From No. 2 a long ridge or bank ran towards the north, and from the other crater another bank went past No. 2 on the west, and advanced in a direction rather west of north, forming a small angle with the other ridge. These two banks were connected by four transverse banks, two of which—the more northerly—extended beyond the longitudinal bank to the west. Neither this latter bank nor crater No. 2 was represented by Lohrmann, nor in Dr. Schmidt's map do I find a trace of either one or the other. From the very peculiar and striking character of the formation, and its association with the phantasies of Gruithuisen, it might naturally be considered to have strong attractions for an observer like Dr. Schmidt, and such appears to have really been the case, for in his descriptive letterpress accompanying the map, he declares that Beer and Maedler* succeeded in representing the object better than himself; and this strikes me as signifying close and repeated observations on the part of Dr. Schmidt. I have not seen Beer and Maedler's work referred to, and cannot say whether the bank and crater in question are to be found there or not; but in any case I should scarcely believe those features to be new, and should be more inclined to regard them as affording striking examples of the oversights of even the best observers. I say this, however, without offering any opinion respecting Dr. Klein's crater, or any theory which it might be considered to support.

* In their work relating to the physical condition of the heavenly bodies, published at Weimar in 1841.